DEMMIN - Test Site for Remote Sensing in Agricultural Application

Borg, E., Fichtelmann, B., Schiller, C., Kuenlenz, S., Renke, F., Jahncke, D., Wloczyk, C.

German Aerospace Center (DLR)
German Remote Sensing Data Center (DFD)

Joint Experiment for Crop Assessment and Monitoring (JECAM)

Agriculture and Agri-Food Canada

Ottawa, Canada, 21-23 July 2014

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Research Areas of DLR

- Aeronautics
- Space Research and Technology
- Transport
- Energy
- Defence and Security (interdisciplinary topic)

- Space Administration
- Project Management Agency

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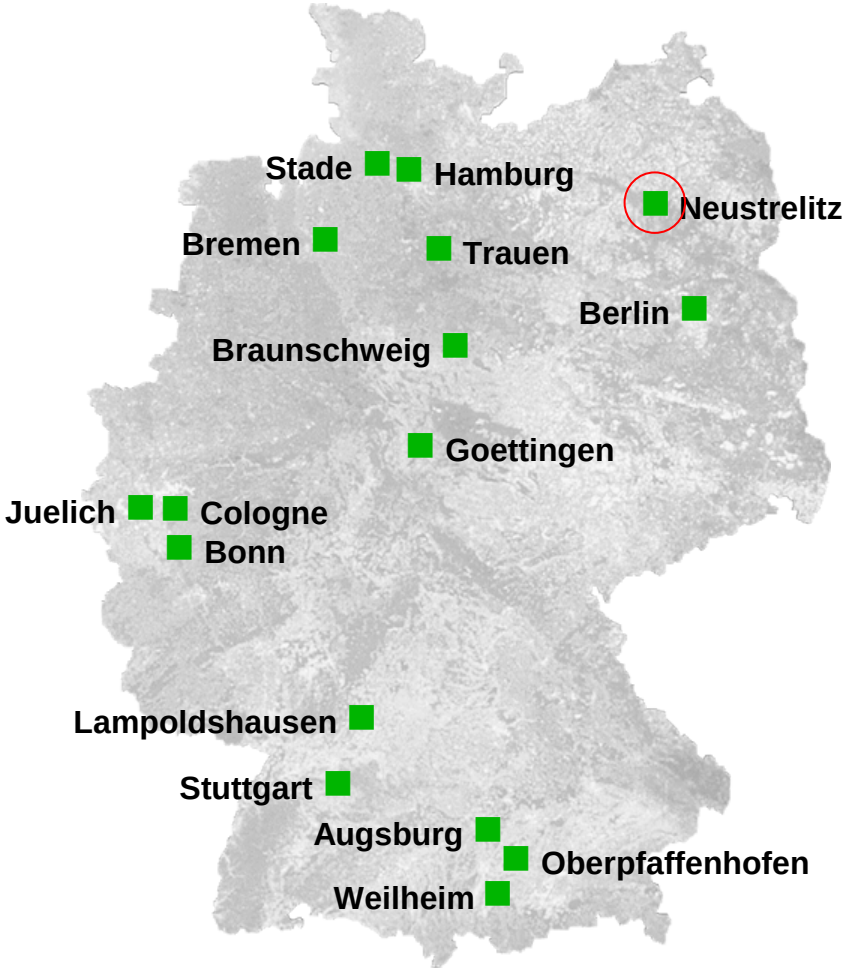
Locations and employees

7700 employees across
32 institutes and facilities at
16 sites.

Offices in Brussels, Paris,
Tokyo and Washington.



DLR Neustrelitz

- Satellite stations of DLR institutes and facilities:
  - German Remote Sensing Data Center (DFD)
  - DLR Remote Sensing Technology Institute
  - DLR Institute of Communications and Navigation

- DLR Technology Marketing
- DLR_Campus Neustrelitz

- DLR Location Neustrelitz: 65 – 70 scientists and technicians

- Companies: euromap, HeJoe

German Remote Sensing Data Center (Prof. Dr. S. Dech)

Department National Ground Segment (H. Maass – holger.maass<@>dlr.de)

The department handles the reception, processing and interim archiving of payload data for e.g. ERS-2, IRS-1C/D, IRS-P3, Landsat-7, CHAMP, GRACE, TerraSAR missions.

The work is partly carried out as a national undertaking and partly on behalf of ESA, private industry, and in cooperation with international space agencies.

- Permanent receiving station for small remote sensing and science satellites
- Automatic, operational-quality processing and archiving center activities for missions, including NRT (near-real-time) processing and data dissemination
- Development of hardware components and software tools for receiving, processing and archiving satellite data.

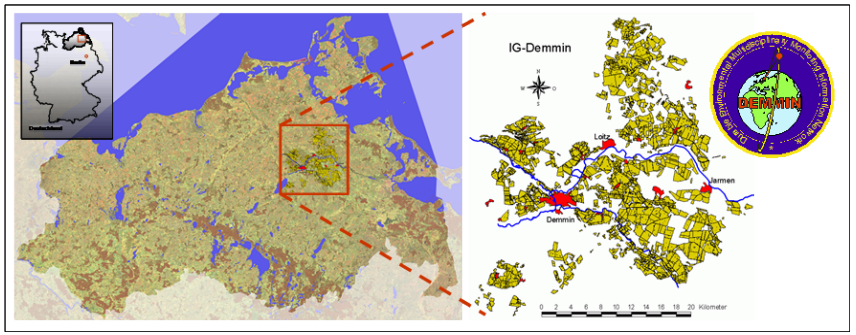
Why do we need a calibration and validation test site for Earth observation?

Remote Sensing includes diverse e.g. platforms, sensors, methods for interpretation

There is an urgent requirement for in-situ-data for validation of value added data

Cal-val of remote sensing requires numerous environmental parameters

Requirement for operationally measured cost- and labour-effective in-situ-data



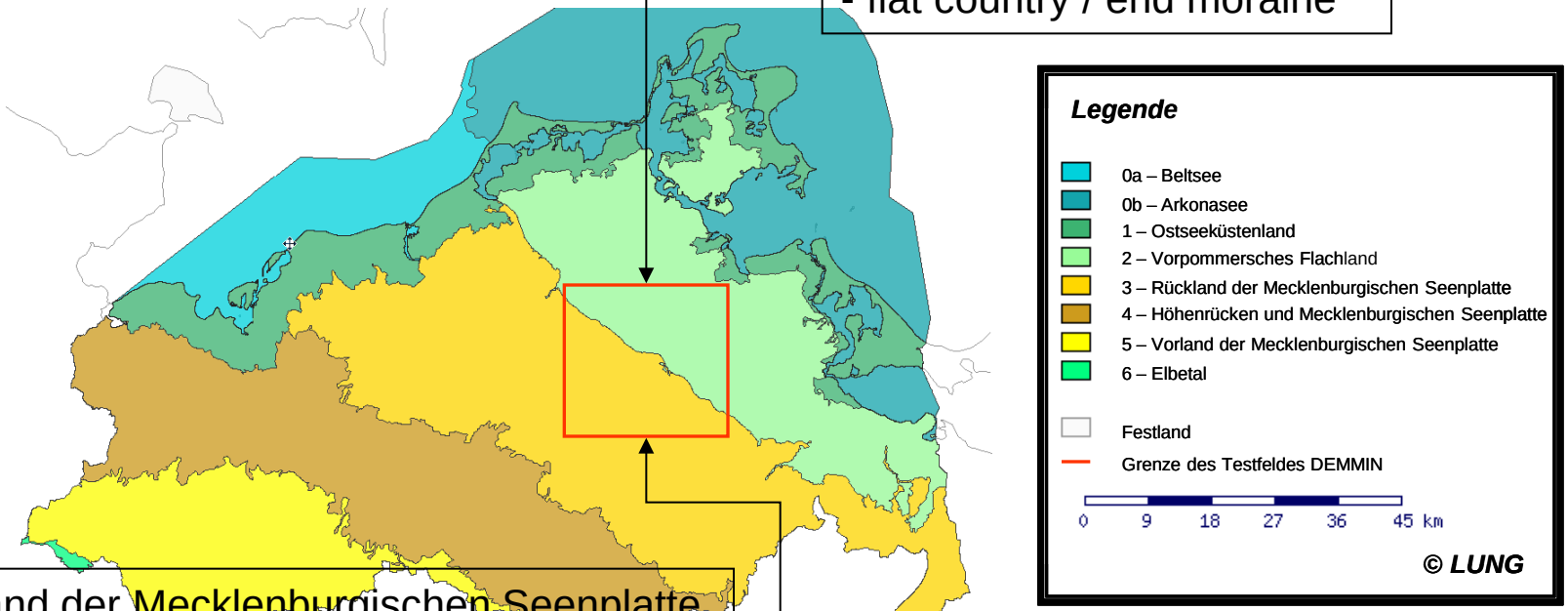
Durable Environmental Multidisciplinary Monitoring Information Network (DEMMIN)

- Cooperation with Farmers (approx. 30,000 ha)
- Size of test-site: 50 km * 50 km

Borg, E., Lippert, K., Zabel, E., Löpmeier, F.J., Fichtelmann, B., Jahncke, D., Maass, H. (2009): DEMMIN – Teststandort zur Kalibrierung und Validierung von Fernerkundungsmissionen.- In: 15 Jahre Studiengang Vermessungswesen – Geodätisches Fachforum und Festakt, Neubrandenburg, Eigenverlag (Hrsg.: Rebenstorf, R.W.).- 16.-17.01.2009.- S. 401-419.

Landscape Zones

Vorpommersches Flachland
- flat country / end moraine



Rückland der Mecklenburgischen Seenplatte
- hilly country / ground moraine

Formation of observatory DEMMIN with respect to landscape zones

(http://www.umweltkarten.mv-regierung.de/script/)

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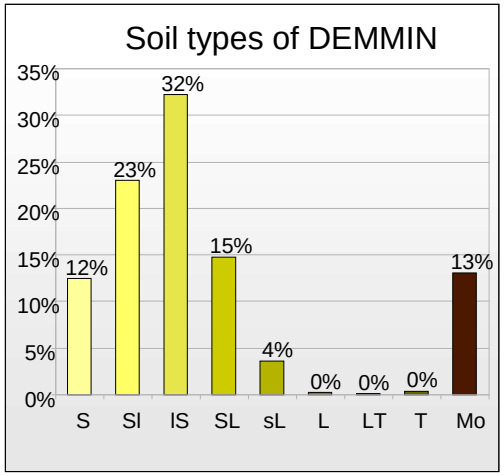
Hydrology and Soil Cover



Hydrological Characterization:

- diffuse, undeveloped water network,
- innumerable lakes and water filled hollows (germ: Sölle)
- Peat bogs along the rivers

Rivers: Trebel, Tollense, Peene
Lakes: Kummerower lake - 0.2 m above sea level Baltic See
Malchiner lake - 0.6 m above sea level Baltic See

Peene: approx. depth 2 - 3 m; approx. slope 0.03%

Pedological Characterization:

- Sand to sandy-loam soils
- Heterogeneous soil cover

Borg et al. (2009)

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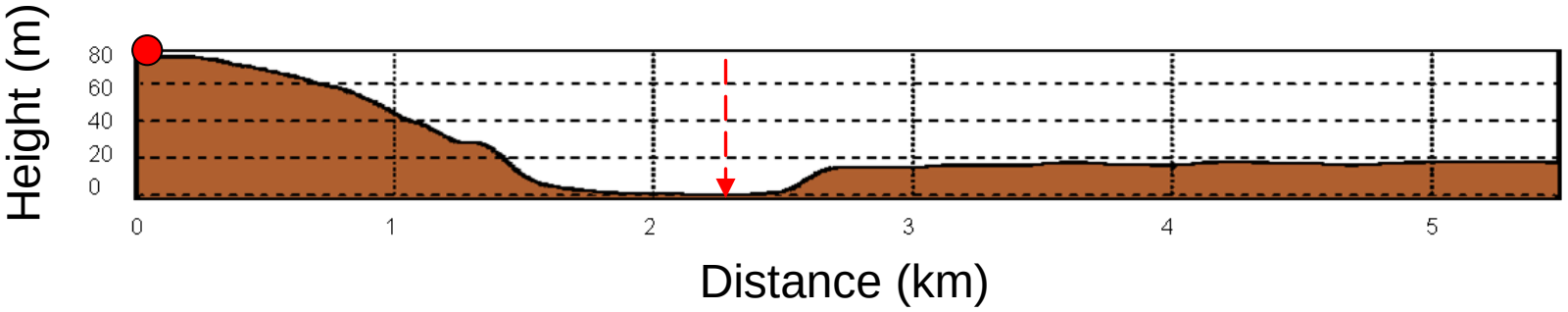
Relief

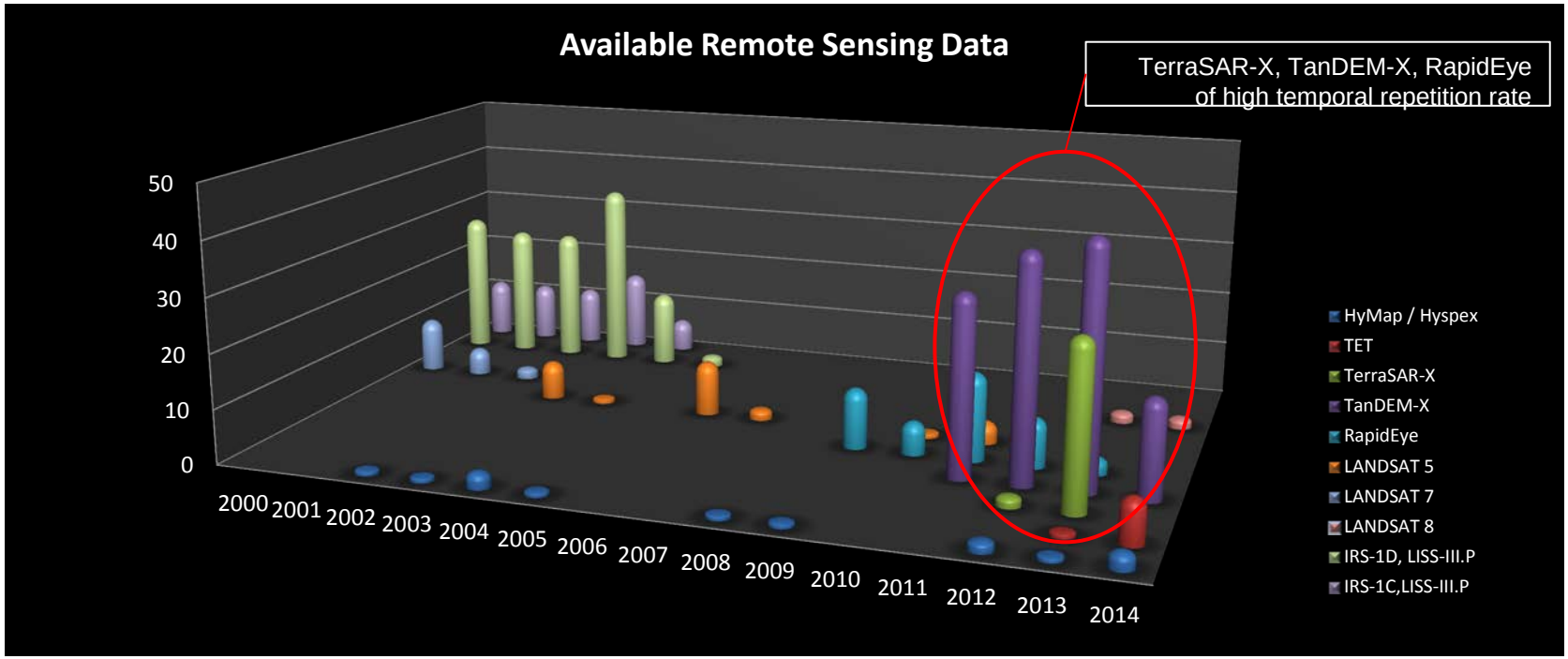
View in the Tollense valley near the village Buchholz



Altitude profile along the view in the Tollense valley. The red pointer assigns the river bed of the Tollense river.

Borg et al. (2009)

Available Remote Sensing Data (Exemplarily)



Available data:

- Hyper-spectral data (e.g. HyMap, Hyspex)
- Multi-spectral data (e.g. IRS, RapidEye)
- Thermal data (e.g. LANDSAT, TET)
- RADAR data (e.g. TerraSAR-X, Tandem-X)

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Available Environmental and Agricultural Data

Data Set	Period of Time
Yield Maps	2000 – 2008
Crop Maps	2000 – 2013
Measurement Data	2004 - 2014

Available agronomic process data (e.g. yield and crop maps) and in-situ-data of automated environmental measurement network (e.g. agro-meteorological data)

Mean Size of fields is 80 ha and in maximum 300 ha.

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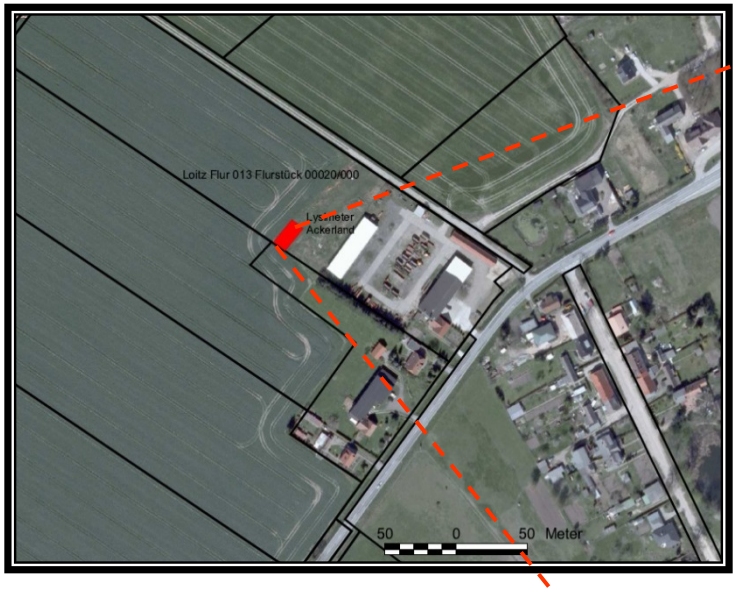
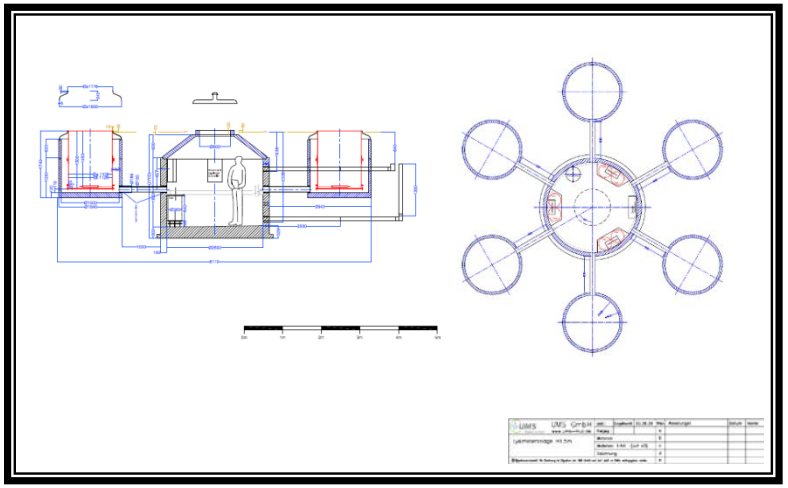
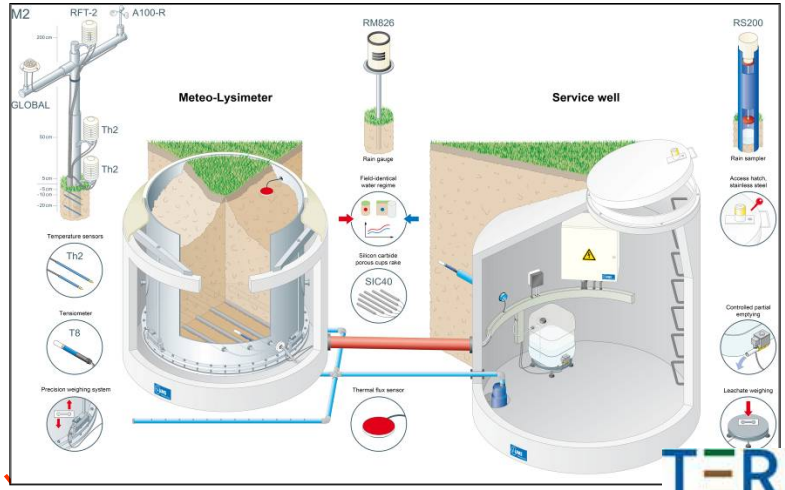
Lysimeter Station: Context TERENO SoilCAN







- Automated lysimeter station Rustow –
- 6 metal cylinder filled with undamaged soil monoliths placed on a balance

Von Unold, G. (2011): http://www.ums-muc.de/lysimeter_systeme/lysimeter/meteo_lysimeter.html (last access: 18.08.2013)

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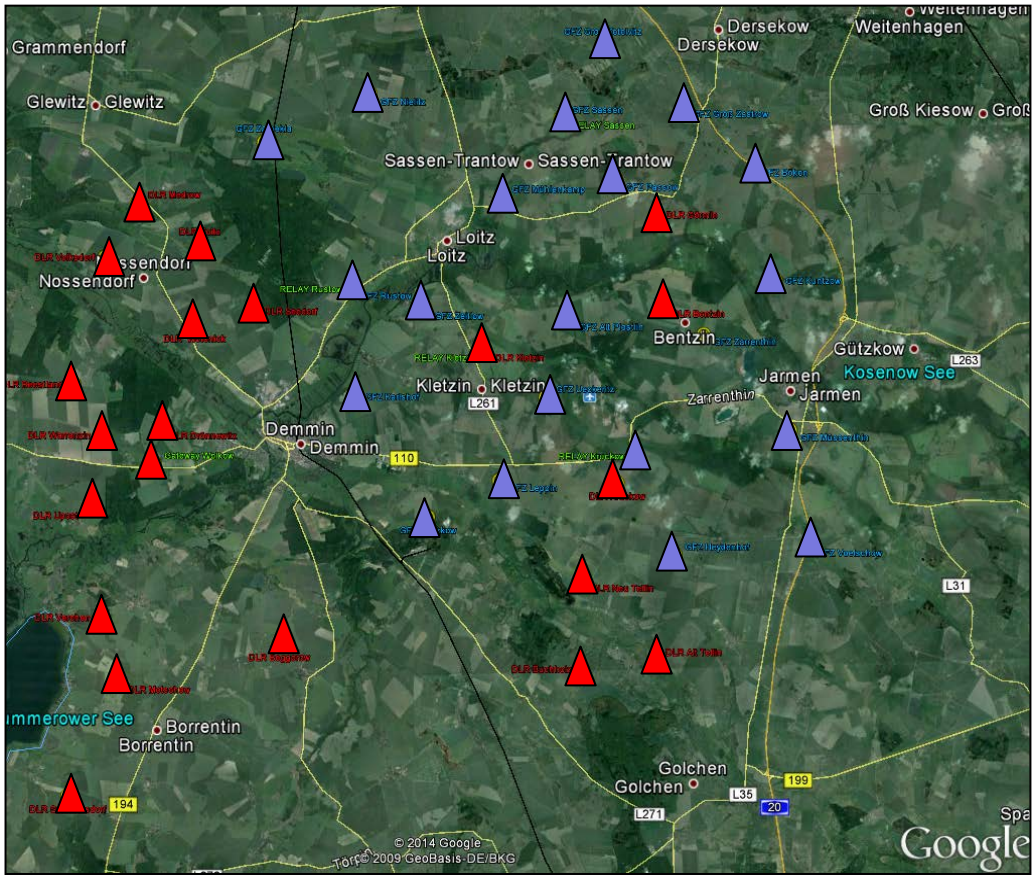
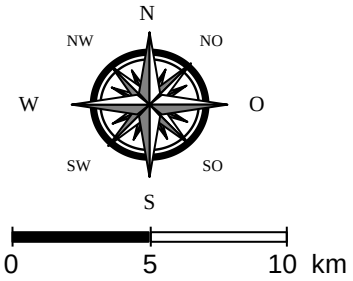
Environmental Measurement Network



Environmental Measurement Station

German Aerospace Center

Geo-Research Center, Potsdam



- 40 environmental stations,
- Measurement interval 15 minutes-slot = 900 sec, 15 samples,
- Data transfer via telemetry transfer,
- Web-data access on data server
- plus approx. 70 soil moisture probes

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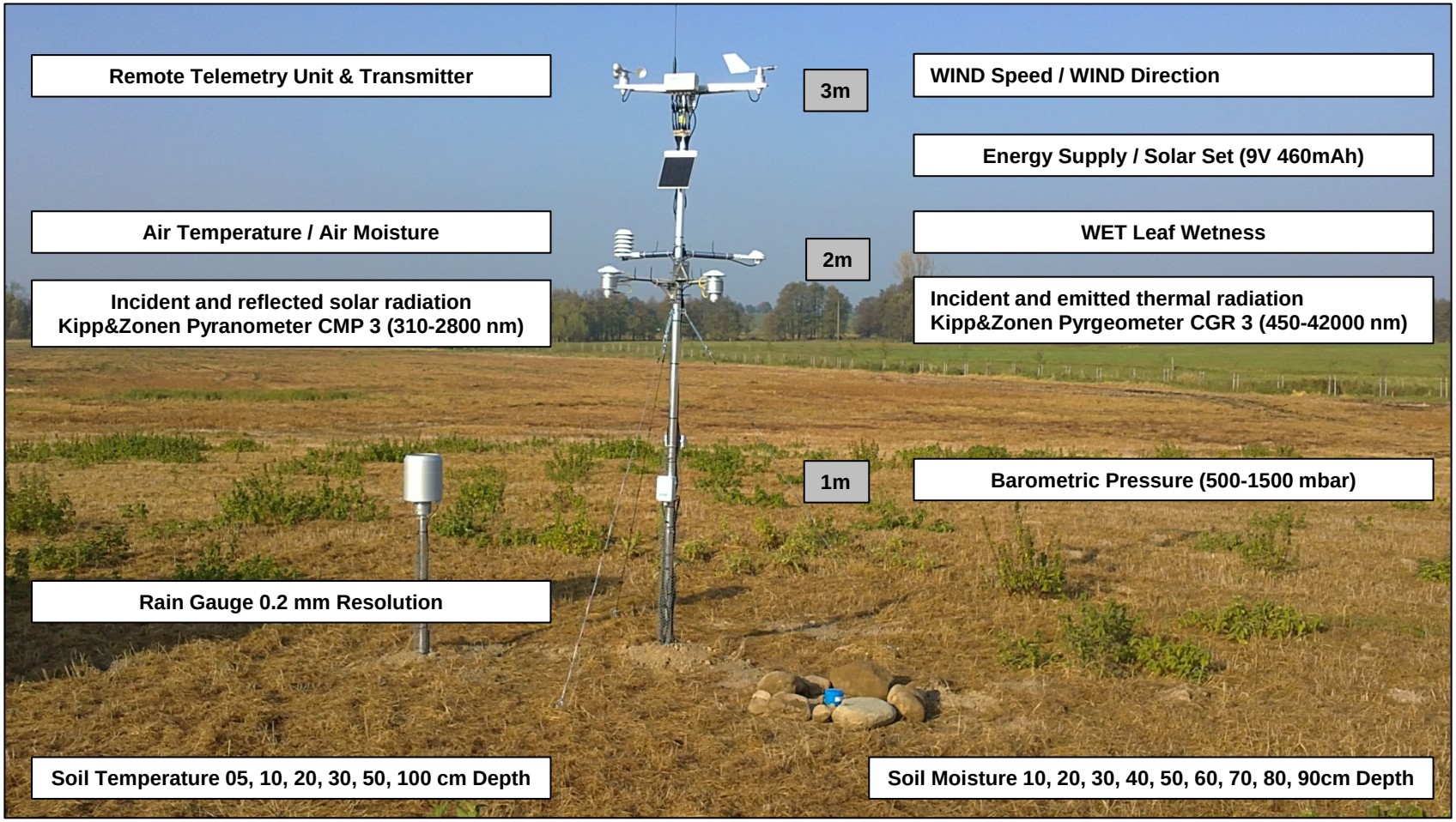
Environmental Measurement Network - Station



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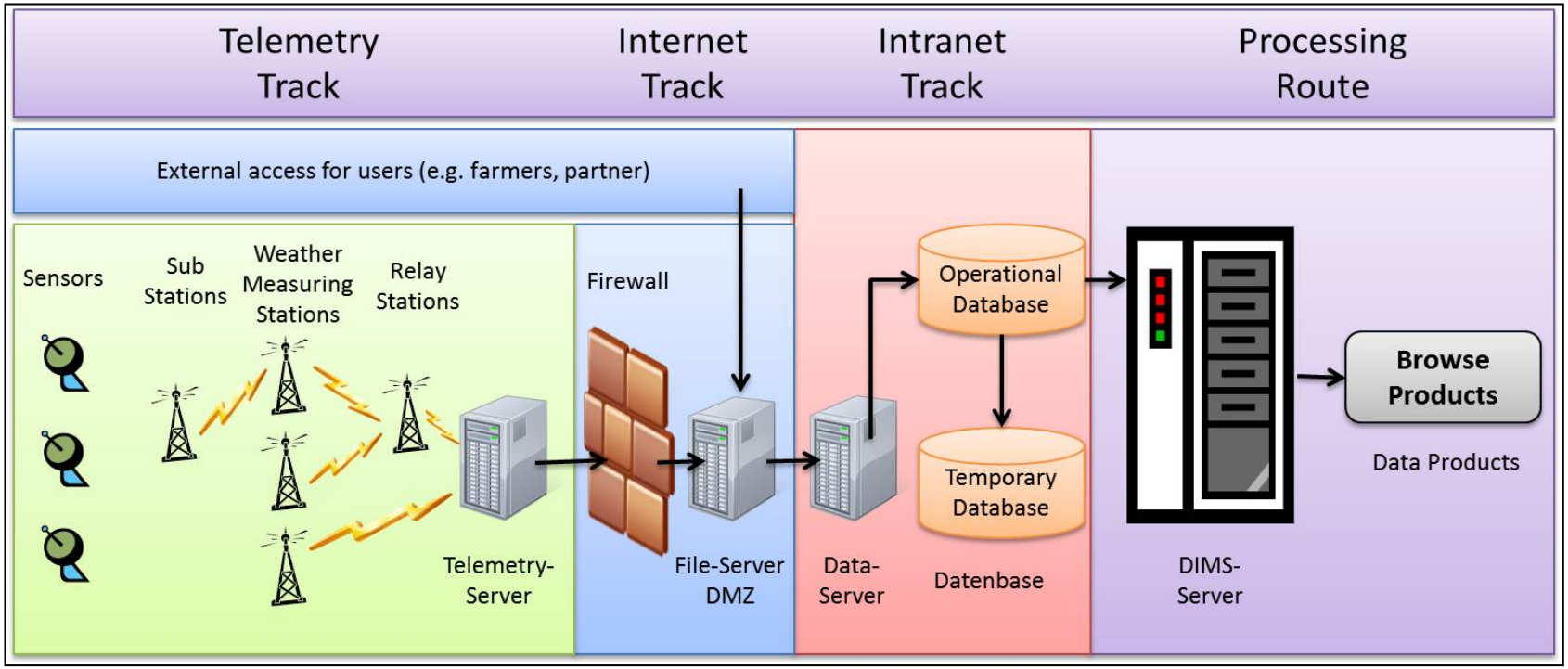
Operative Processing Chain for In-situ-Data



Borg, E., Schiller, C., Daedelow, H., Fichtelmann, B., Jahncke, D., Renke, F., Asche, H. (2014): Automated Derivation of Value Added Information Products on Basis of In-Situ-Data for Validation of Remote Sensing Data.- 12th International Conference on Computational Science and Applications (ICCSA 2013), Portugal.- in press.

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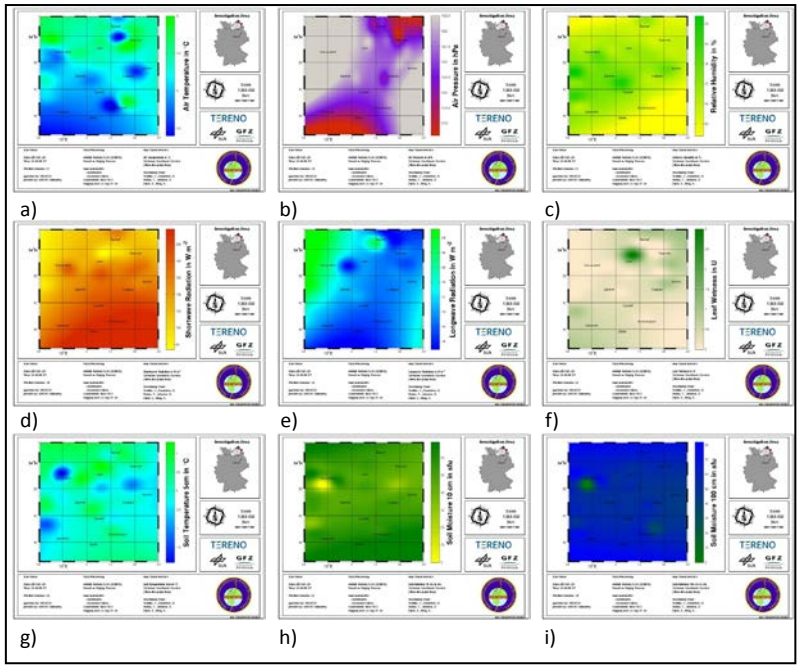
In-situ-Data Browse Products



Sample products showing parameter distribution of a) air temperature, b) air pressure, c) relative humidity, d) shortwave, e) longwave radiation, f) leave wetness, g) soil temperature – 5 cm, h) soil moisture – 10 cm, i) soil moisture – 100 cm (http://demminweb.dlr.de)

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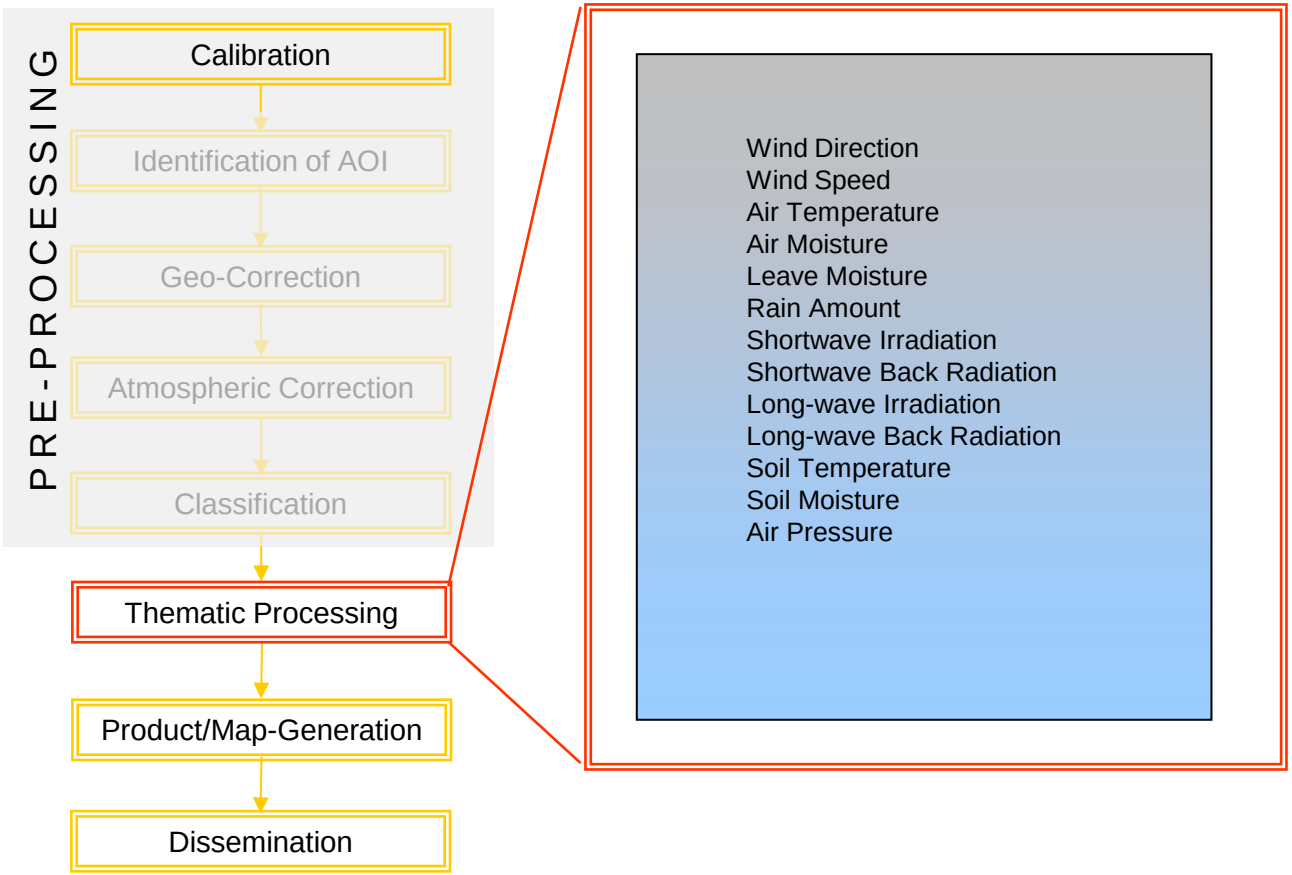
In-situ-Data Processor: Evapotranspiration



Legend

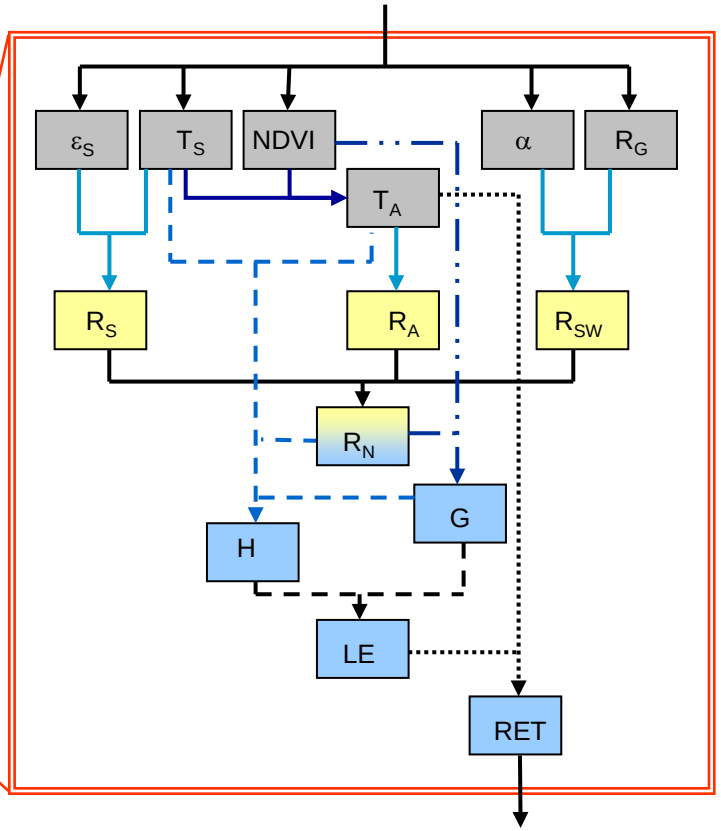
L^*	*Heat of vaporization*
s	*slope of the saturation vapor pressure curve*
R_n	*Net radiation*
G	*Ground heat flux*
ρ	*Density of air*
c_p	*Specific heat of air*
r_a	*Aerodynamic Resistance*
$e_s(T)-e$	*Saturation deficit, f=(T, e)*
γ	*Psychrometer constant*
r_s	*Stomata resistance*
T	*Air temperature*
e	*Vapour pressur*

$$ETa = \frac{1}{L^*} \cdot \frac{s \cdot (R_n - G) + \frac{\rho \cdot c_p}{r_a} \cdot (e_s(T) - e)}{s + \gamma \cdot \left(1 + \frac{r_s}{r_a}\right)}$$

Remote Sensing: Evapotranspiration

PRE-PROCESSING

- Calibration
- Identification of AOI
- Geo-Correction
- Atmospheric Correction
- Classification
- Thematic Processing
- Product/Map-Generation
- Dissemination



Legend

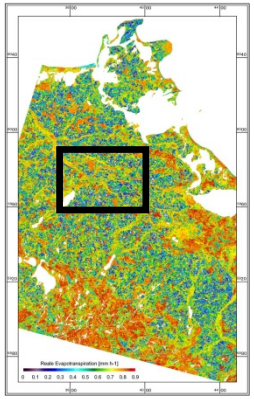
ε_S	*surface emissivity*
α	*albedo*
T_S	*surface temperature*
T_A	*air temperature*
R_G	*incident (or global) solar radiation*
R_S	*emitted surface radiation*
R_A	*atmospheric longwave radiation*
R_N	*net radiation*
R_{SW}	*shortwave net radiation*
H	*sensible heat flux*
G	*ground heat flux*
LE	*latent heat flux*
RET	*actual evapotranspiration*
NDVI	*normalized difference vegetation index*

Basic Parameters
Radiation Components
Components of Energy Balance

Richter, R. (2003): Value Adding Products derived from the ATCOR Models (Version 5.5, January 2003).- p. 28. http://www.rese.ch/pdf/atcor_value_adding.pdf

Wloczyk, C. (2007): Entwicklung und Validierung einer Methodik zur Ermittlung der realen Evapotranspiration anhand von Fernerkundungsdaten in Mecklenburg-Vorpommern. Dissertation, S. 143, ISBN: 978-3-86009-010-7

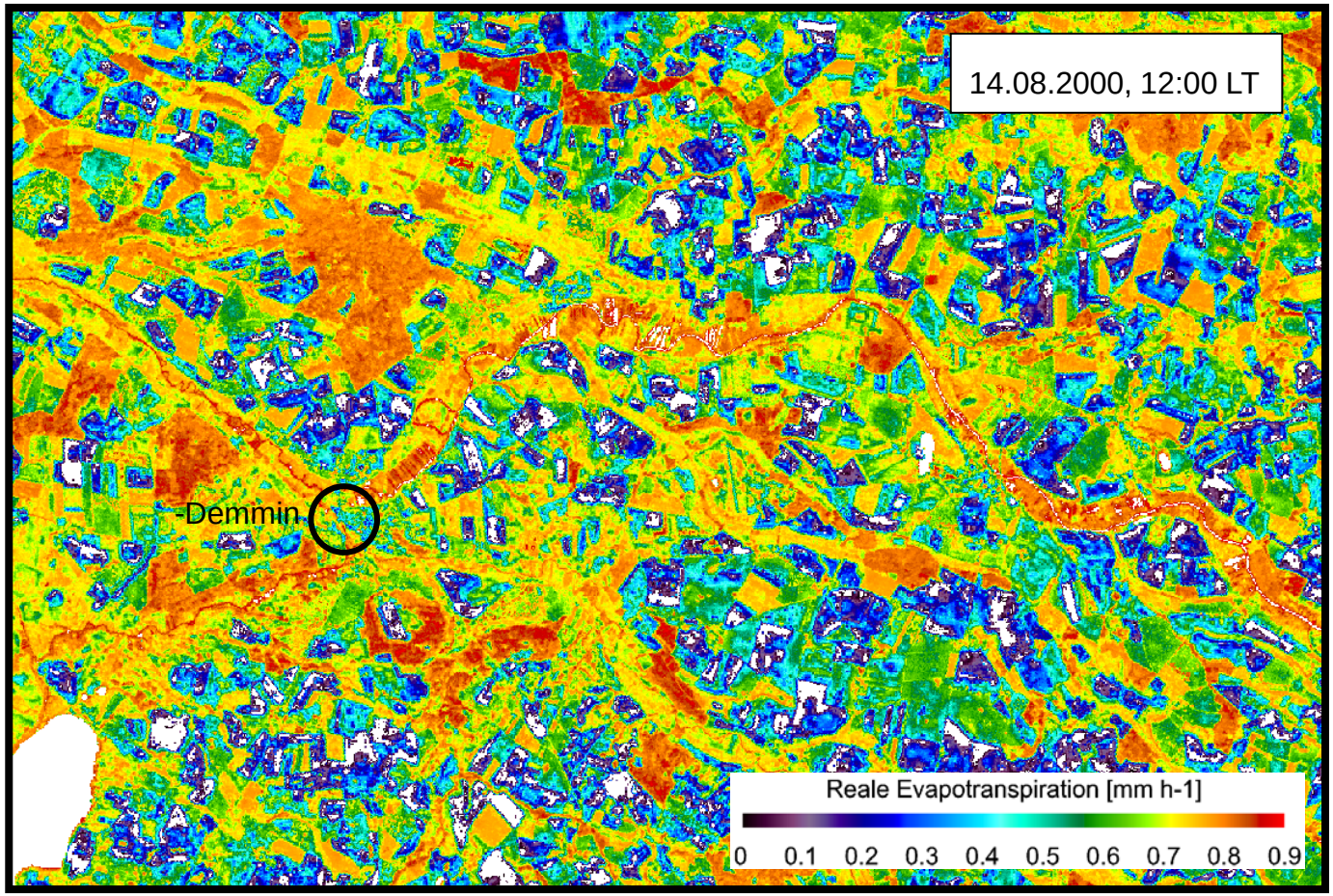
Remote Sensing: Evapotranspiration DEMMIN



Estimated hourly evapotranspiration, based on one instantaneous value

Cloudless sky

Water surfaces masked (Baltic Sea, lakes)



Results of the Experimental RealET-Processor

Accuracy:

• surface temperature	approx. +/-2 K,
• air temperature	approx. +/-3 K,
• solar radiation	approx. +/-20 W m^{-2}
• actual evapotranspiration	approx. +/-50%

The approach has been assessed as robust.

WLOCZYK, C., RICHTER, R., BORG, E., NEUBERT, W. (2006): Sea and lake surface temperature retrieval from Landsat thermal data in Northern Germany. *International Journal of Remote Sensing*, **27**(12), 2489–2502.

WLOCZYK, C., RICHTER, R. (2006): Estimation of incident solar radiation on the ground from multispectral satellite sensor imagery. *International Journal of Remote Sensing*, **27**(6), 1253-1259.

WLOCZYK, C., BORG, E., RICHTER, R., MIEGEL, K. (2011): Estimation of instantaneous air temperature above vegetation and soil surfaces from Landsat 7 ETM+ data in northern Germany. *International Journal of Remote Sensing*, **32**(24), 9119-9136.

Lessons learned from the experiment

Complex processor → a number of intermediate products can be derived

Meteorological station network of German Meteorological Service (DWD):

- intended use: weather forecast, securing (air) traffic…
- validation of remotely sensed parameters:
  - no intended use!
  - station density and distribution partly inappropriate
  - some parameters needed for evapotranspiration estimation are not measured (e.g. radiation parameters)

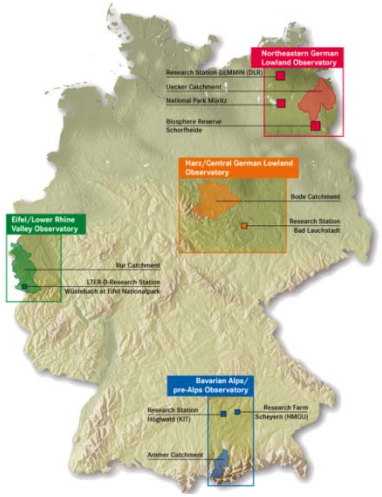
→ dedicated meteorological / hydrological measurements are needed for validation of remotely sensed evapotranspiration

→ DEMMIN

Cooperation

TERENO-Initiative (TERrestrial ENvironmental Observatories):

• surface temperature	approx. +/-2 K,
• air temperature	approx. +/-3 K,
• solar radiation	approx. +/-20 W m^{-2}
• actual evapotranspiration	approx. +/-50%



Observatorium
Nordostdeutsches
Tiefland
Koordination: GFZ

Observatorium
Harz / Mitteldeutsches
Tiefland
Koordination: UFZ

Observatorium
Eifel / Niederrheinische
Bucht
Koordination: FZJ

Observatorium
Bayerische Alpen /
Voralpenland
Koordination: KIT / HMGU

TERENO
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nereus
network of european regions using space technologies

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Performed and Planned Campaigns (Selection)

AGRISAR 2006:

- Objective: assessment of Sentinel missions-1 /-2 and improving of interpretation methods for radar and optical data, generation of in-situ and airborne data (weekly), simulation of prospective sentinel data and information products
- Partner: >15 research centers (e.g. University Canfield, University Valencia, Universität Alicante, National Institute for Aerospace Technology, International Institute for Geo-Information Science and Earth Observation, Denmark, Technical University of Denmark, University Gent, German Aerospace Center, ITRES Research.

TERENO (SoilCAN - The German Lysimeter Network)

- Objective: Measurement and documentation of climate-relevant parameters , climate research and climate impact consulting for regional development of climate-sensitive regions
- Partner: 6 research centers (e.g. Research Center Jülich – FZJ, Helmholtz Centre for Environmental Research – UFZ, Karlsruhe Institute of Technology – KIT, German Research Centre for Geosciences – GFZ, German Aerospace Center - DLR) and partners.

TechnologieErprobungsTraeger (TET) 2013:

- Objective: Validation of the fire detection system onboard the TET Mission

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Performed and Planned Campaigns (Selection)

PHENOS (funded by Federal Ministry of Economics and Energy (BMWi), DLR Project Management Agency):

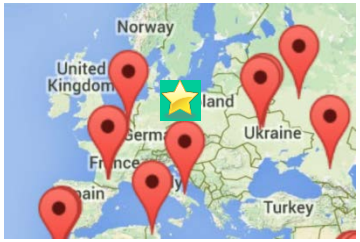
- Objective: development and validation of algorithms / models for the operational detection of optimal phenological time slots for an cost optimized land use classification for Sentinel 2 data.

Tech4Times (funded by Federal Ministry of Economics and Energy (BMWi), DLR Project Management Agency):

- Objective: Validation of remote sensed crop parameters for precise yield estimation

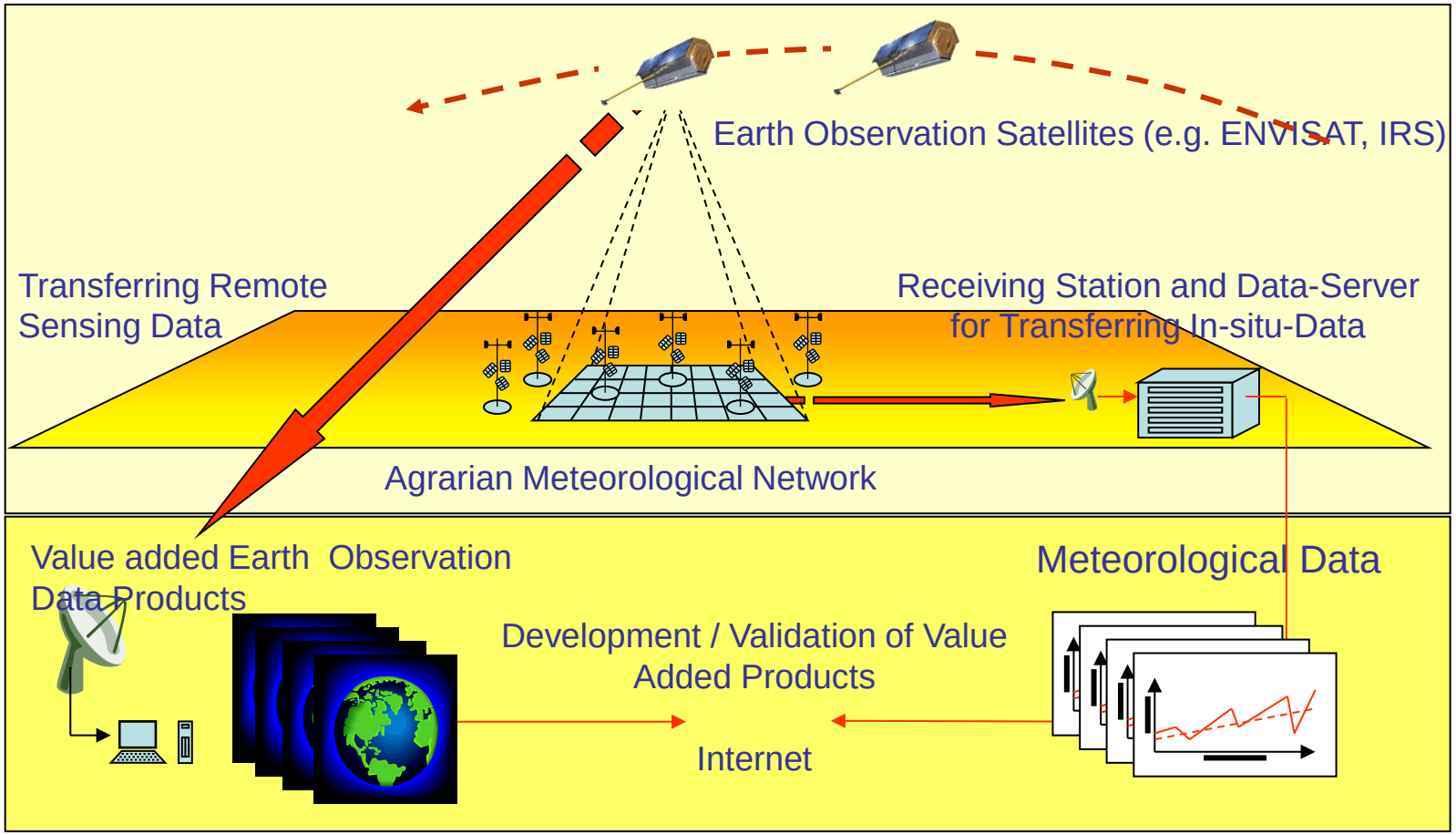
Strategic Planning

- The DLR wants to develop the test site DEMMIN into a technical and technological blueprint for the calibration and validation of remote sensing data, missions, applications, and value added information products.
- The test site DEMMIN measures numerous in-situ data and environmental parameters that affect the remote sensing process.
- The measurements are operationally carried out by semi- and automated cost- and labour-effective measurement infrastructure and measurement strategies.
- DEMMIN is developed to an in-situ-component of the COPERNICUS initiative.



DEMMIN can fill a gap in Central Europe

Measurement Strategy for Remote Sensing



Borg, E. (2010): CAL/VAL Site DEMMIN for Remote Sensing.- In NEREUS – network of European regions using space technology.- Ed.: NEREUS Earth Observation / GMES Working Group.- p. 13-14.

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Thank You for Your Attention!